Meat's Carbon Hoofprint

Barry Brook and Geoff Russell reveal why a family's meat consumption can contribute more to global warming than their four-wheel drive vehicle.

Newspaper stories on methane emissions are often accompanied by a cartoon of farting or belching cattle, and somewhere in the body of the story you will read that 1 tonne of methane is equivalent to 21 tonnes of CO_2. Likewise 1 tonne of nitrous oxide (N_2O) is said to be equivalent to 310 tonnes of CO_2.

This factor is called the global warming potential (GWP) of the gas. This is great for accounting, because you can convert all your different greenhouse gas emissions into a common unit, a CO_2-equivalent (CO_2-e), and add them up – which is exactly what the Australian Greenhouse Office does.

But how are these GWPs calculated, and how do they take into account the varying rates of breakdown of different gases in the atmosphere? First, you need to measure the amount of gas remaining in the atmosphere as a function of time after releasing a tonne of it. This is the decay curve (Fig. 1), and represents the natural breakdown of methane into CO_2 and water.

Next you need to calculate the impact of each molecule on global warming, and multiply by the area under the decay curve. The impact is the change in the radiation balance – which is the difference between the energy of the solar radiation striking the Earth and the thermal radiation leaving the Earth. This radiation balance is expressed as an instantaneous measure of Watts per square metre.

At present, for each square metre of the Earth's surface there is about 1.6 W more energy arriving than leaving. That may not sound like much, but the difference in solar radiation due to slow changes in our orbit around the sun, combined with the wobble and tilt of the Earth on its axis, is a global average of about 0.25 W/m^2. That differential is enough, when amplified by the planet's climate feedbacks, to whip us back and forth between ice ages and warm interglacial periods (such as the present day).

As it happens, CO_2 takes hundreds of years to (mostly) disappear. The decay curve is very long, but the impact is very small.

Accounting procedures established under the Kyoto Protocol use the first 100 years of the decay curve to compare gases. So, to calculate the GWP of a gas, we average the impact of that gas over a period of 100 years and express it as a ratio of the impact of CO_2 over 100 years.

Hence the relative impact of the two gases depends critically on the time period over which you measure it. If, for instance, you compare the impact of methane to CO_2 over a period of 20 years instead of 100 years, then methane has 72 times the impact of CO_2. While a tonne of methane is broken down to CO_2 and water in the atmosphere in 10–15 years, 1 tonne of CO_2 emissions stays aloft and active for much longer. About a one-quarter of that tonne will still be contributing to global warming in 500 years.

Although atmospheric methane levels

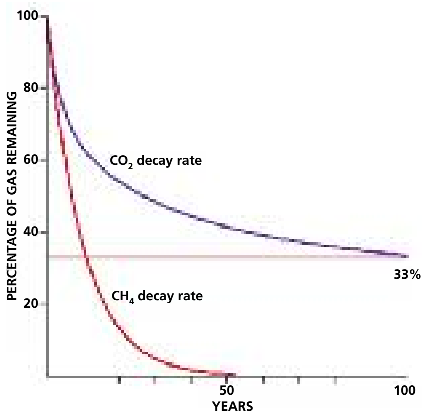

Figure 1. Amount of carbon dioxide (CO_2) and methane (CH_4) that remains in the atmosphere as a function of time.

are tiny, they are now two-and-a-half times their pre-industrial levels. By contrast, carbon dioxide levels are 37% greater. While global warming due to methane is about half that of CO_2, the emissions of some countries – notably Australia, Brazil and India – have an unusual structure due to their high livestock populations.

Temperature Control Now and in the Future

Because CO_2 remains airborne for centuries, it is absolutely essential to reduce CO_2 emissions quickly. Every 4 tonnes added per year adds another tonne that will still be heating us half a millennia later.

So, if we do not act quickly to control CO_2, any actions we take to reduce methane will have little impact on the future climate of our planet. Our descendants will suffer from a globally averaged temperature rise of 3–6°C by 2100, an eventual (and perhaps rapid) melting of the Greenland and West Antarctic ice sheets (with an attendant 12–14 metres of sea level rise), more frequent and severe droughts, more intense flooding, a major loss of biodiversity, and the possibility of a permanent El Niño, with frequent failures of the tropical monsoons that provide the conditions required to feed the billions of people in Asia.

But the optimistic view is that we, as a collective and forward-thinking society, make the necessary economic and technological choices required to mitigate our CO_2 emissions dramatically. If this decision is made, then methane and other greenhouse gases become extremely important. Why?

First, methane is a very powerful greenhouse gas with a relatively short lifetime, such that methane reductions can impact the radiation balance relatively quickly.

Second, while CO_2 emission reductions are complex and costly because they cut across some many economic sectors, mitigation of methane emissions is generally far simpler. For example, Australia had 170 million sheep in 1990 and it has about 92 million now. This reduction was driven by market forces and was not planned, but it does show how rapidly methane reductions can happen.

How Much Methane Does Our Livestock Produce?

Figures about litres of gas per cow per day don't mean much to most people. The easiest way to get a feel for the numbers is to compare livestock emissions with some other emissions with which people are more familiar.

We have more cattle than people in Australia, and five sheep for every person. We don't run air conditioners 24 hours per day, 7 days per week, nor do we individually drive our vehicles non-stop. But cattle and sheep, via their fermenting gut bacteria, produce methane continuously, day and night.

Annually, Australian livestock produce about 3 million tonnes (Mt) of methane. Using the 100-year GWP, this 3 Mt of methane represents 63 Mt of CO_2-e. As a comparison, all of Australia's passenger vehicles produce about 43 Mt of CO_2. Using the 20-year factor of 72 (which comes from the Intergovernmental Panel on Climate Change's Fourth Assessment Report), it is clear that this 3 Mt has an impact on global warming, during the following 20 years, that is equivalent to 216 Mt of CO_2 emissions. This is more than the atmospheric heating caused by emissions from all of Australia's coal-fired power stations!

Hence methane reductions offer a unique opportunity to rapidly and effectively reduce our global warming footprint. By improving the radiation balance quickly, they can buy us time while CO_2 reduction technologies are being developed and deployed. This is a somewhat ironic situation given that wide-scale uptake of gas-fired power stations instead of coal is another way for us to buy time.

A reduction in methane emissions allows us to reduce the radiation imbalance relatively quickly, which is something that CO_2 reductions cannot do. In the US, methane emissions from livestock are smaller than those from landfill, gas leaks and emissions from coal mining. This is partly because the US has one head of cattle for every three people compared with Australia's ratio, which is the highest on the planet. In addition, US cattle are fed grain in feedlots, which results in far less methane than grass-fed cattle. In Australia, livestock methane emissions constitute about 60% of all methane emissions.

Comparing Diet and Motoring

Some comparisons help to illustrate the ways in which such emission reductions can be achieved. Livestock greenhouse emissions don't stop with methane. The Australian Greenhouse Office has calculated a 100-year greenhouse intensity of 55.5 kg of CO_2-e per kg of beef. This is more than double the emissions per kg of aluminium.

That 55.5 kg is calculated using the 100-year GWP, and is an emission figure per kg of carcass. However, the emissions per kg of actual red meat eaten are around 80 kg of CO_2-e per kg. Over a 20-year period, the figures are considerably higher (Table 1).

Table 1. Emission intensity of some common foods expressed as kilograms of carbon dioxide-equivalent (CO_2-e) released into the atmosphere for each kilogram of production. For foods that produce copious amounts of methane, the 20-year figures are substantially higher than over a 100-year time frame. Source: Australian Greenhouse Office

Food	kg CO_2-e/kg (20 years)	kg CO_2-e/kg (100 years)
Beef	111.1	55.5
Sheep meat & wool	96.3	32.7
Pig meat	10.5	3.5
Rice	2.4	0.74
Poultry	1.3	0.38
Wheat	0.35	0.32

Now let us compare the emissions of a family of four eating in accordance with the *CSIRO Total Wellbeing Diet*, where the family car is a 2-tonne Ford Territory. It takes about 17 tonnes of emissions to build a tonne of motor vehicle, and the Territory generates about 300 g/km of use. So if the family vehicle is driven 200 km/week, then that is 60 kg of emissions from travelling. The family could be eating 5.6kg of beef per week, at 200 grams of red meat per day, but if we are conservative and put them on 4 kg of beef per week the CO_2-e emissions associated with the beef are well over 200 kg/week. Thus the family's emissions from beef consumption will easily outweigh the construction and running emissions of the Territory in about 5 years.

Conclusions

Most public information and campaigns, about how people can reduce their global warming footprint are based around a conceptual model of the causes of global warming, in which power stations and automobiles are the only greenhouse gas emitters worthy of consideration. This has given methane a very low public profile even though it is the second most important greenhouse gas after CO_2. Globally, enteric fermentation from livestock (predominantly ruminants) is the biggest anthropogenic source of methane, with traditional red meat producing about double the methane of rice growing for a mere 10% of the food calories. In this sense the "carbon intensity" of beef is about 20 times greater than rice.

Countries like Australia and Brazil already have more cattle than people, and China, whose traditional staple is rice, is witnessing a steep rise in cattle numbers. These huge and growing ruminant populations are a threat to serious attempts to reduce the planet's radiation imbalance, and hence to our ability to stave off dangerous levels of climate change.

In Australia, significant methane reductions, due to the drop in our sheep population, have been largely squandered by allowing unfettered growth in our cattle population. Furthermore, our premier scientific research organisation is promoting a diet and method of eating that will support and encourage further growth in ruminant populations.

Many strategies will be needed to reduce Australia's greenhouse emissions across all economic sectors, but we cannot afford to ignore ruminant reduction as an effective strategy. At a personal level, in addition to the many CO_2-saving initiatives that are regularly promoted, you can contribute to tackling this problem by eating less red meat (Table 1). Even one less red meat meal per week can make a significant difference to your greenhouse footprint.

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THE GLOBAL WARMING POTENTIALS OF DEODORANTS

Ozone-layer-destroying chemicals called chlorofluorocarbons (CFCs) were used in deodorant and other spray cans on an industrial scale from the 1960s, and phased out due to the 1987 Montreal Protocol. Like methane, they are also greenhouse gases of great potency on a per-molecule basis, but are broken down quickly. If you express CFCs in CO_2-e, and if you look at the growth of CFCs prior to the 1987 Montreal Protocol, you can estimate the amount of CO_2-e emissions that Montreal has saved. This calculation shows that, by 2012, the Montreal Protocol will have prevented the equivalent of between 9.7 and 12.5 billion tonnes of CO_2 being pumped into the atmosphere every year. On the other hand, if all countries meet their Kyoto targets by 2012, we will save the equivalent of only about 2 billion tonnes of CO_2 per year. You can also show that, if CFCs had continued to grow at their 1970s growth rates, they would be the gases having the biggest impact on global temperatures today (they would have also almost completely destroyed the ozone layer). Were it not for their other stratospheric side-effects, perhaps we would be setting up deodorant-trading schemes to control them!